ArcheoTUI - Tangible interaction with foot pedal declutching for the virtual reassembly of fractured archeological objects

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Abstract

In this demonstration, we present ArcheoTUI, a new tangible user interface for the efficient assembly of the 3D scanned fragments of fractured archeological objects. The key idea is to use tangible props for the manipulation of the virtual fragments. In each hand, the user manipulates an electromagnetically tracked prop, and the translations and rotations are directly mapped to the corresponding virtual fragments on the display. For each hand, a corresponding foot pedal is used to clutch the movements of the hands. Hence, the hands of the user can be repositioned, or the user can be switched. The software of ArcheoTUI is designed to easily change assembly hypotheses, beyond classical undo/redo, by using a scene graph.

CR Categories: I.3.1 [Computer Graphics]: Input devices—[I.3.6]: Computer Graphics—Interaction Techniques H.5.2 [User Interfaces]: Input devices and strategies—

Keywords: tangible user interfaces, 3D interaction

1 Motivation

Cultural objects of archeological findings are often broken and fractured into an innumerable amount of fragments (Figure 2). A common tedious and time-consuming task for archeologists is to reassemble the fractured objects. So to speak, large 3D puzzles have to be solved. Scanning the fragments and reassembling the corresponding 3D objects virtually is an elegant (and sometimes the only) solution (Figure 3). An efficient user interaction for the complex task to orientate or position two 3D objects relative to each other is essential, eventually in addition to automatic matching techniques. We designed ArcheoTUI on the demand of archeaologists and in a direct collaboration with them with in order to make it possible for them to virtually solve the 3D puzzle.

2 Interaction techniques

When assembling two fragments, the user has to manipulate two times 6DOF at a time, and classical user interfaces such as the 2D mouse or the keyboard are impractical for this assembly task. Our work is inspired by the seminal work of Hinckley et al. [Hinckley et al. 1994] where passive real-world interface props are used for neurosurgical visualization. In our ArcheoTUI interface, the user manipulates a prop in each hand, and the translations and rotations are directly mapped to the corresponding virtual objects on the display.

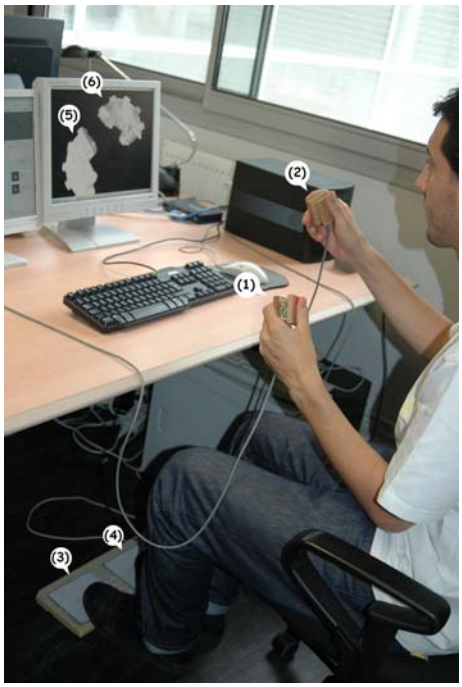

Figure 1: *The ArcheoTUI user interface.*

ArcheoTUI can be considered as a tangible user interfaces (TUI): the tangible part, two wooden blocks, can be moved and rotated, and the visualization provides visual feedback. Ishii and Ullmer [Ishii and Ullmer 1997] defined tangible interfaces as user interfaces that ”augment the real physical world by coupling digital information to everyday physical objects and environments”.

In our context, the archeological fragments that have to be assembled are rather complex. In order to limit the cognitive load, only two fragments can be assembled at a time. Consequently, we propose a bi-manual interaction [Guiard 1987] with two props.

We integrated two different interaction techniques in order to associate (and dissociate) the movements of the props to the virtual fragments: two foot pedals (Figure 1, items 3 and 4), and buttons on the props (Figure 4). A declutching mechanism with only one foot pedal was already used by [Hinckley et al. 1994], and we extended this metaphor to two foot pedals.

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Figure 2: *Photos of the fractured fountain parts.*

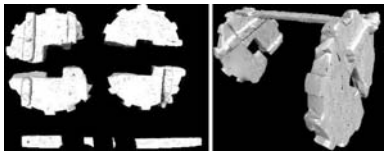

Figure 3: *The virtual fragments and the assembly.*

3 The design of ArcheoTUI

The key idea of the ArcheoTUI system is to use props as physical representation and control for the scanned virtual fragments. For an illustration, consider the 6 items of the set-up of the ArcheoTUI system in Figure 1. In each hand, the user manipulates a prop (items 1 and 2). The props can be freely positioned and oriented in space. For each prop, there is a corresponding foot pedal (items 3 and 4). Only when the corresponding foot pedal is pressed down, the translations and rotations are directly mapped to the corresponding virtual fragment on the display (items 5 and 6). Consequently, the user gets a sort of passive haptic feedback when manipulating the props. Once the foot pedal is released, the movement of the corresponding prop is dissociated from the virtual fragment. Consequently, the position and orientation of the virtual fragment is fixed, and the hands of the user can be repositioned. This is especially useful when the user feels uncomfortable about his arm positions, or when the physical props collide with each other. Thanks to this declutching mechanism, the user can also be switched while the virtual fragments stay in position, and thus another user can propose new assembly hypothesis.

We implemented the software for ArcheoTUI in C++ on a Linux Workstation. We used Qt for the graphical user interface and OpenSG for the rendering backend. The assembly of the pieces is represented in a scene graph, and the interior nodes contain the transformations that are specified during the user interaction. The broken fragments are organized in an SQL database that we integrated using SQLite.

4 Discussion and conclusions

We conducted two user studies on site at the workplace of the archeologists. The first user study revealed that the interface, and especially the foot pedal, was accepted, and that all the users managed to solve simple assembly tasks efficiently [Reuter et al. 2007]. In a second user study, we compared the different clutching mechanism with buttons on the props to the foot pedal mechanism. This second user study revealed that the movement of the hands is more similar to real-world assembly scenarios when using the foot pedals, and that the users can keep on concentrating on the actual assembly task.

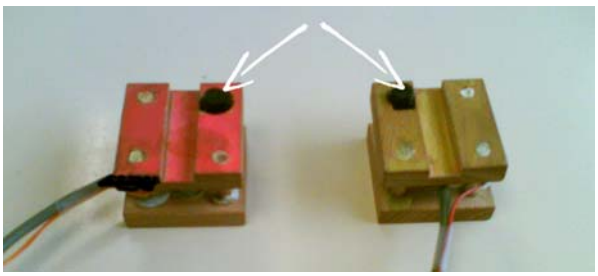

Figure 4: *The props with buttons for declutching.*

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